# Status of a broadly distributed endangered species: results and implications of the second International Piping Plover Census

**Jonathan H. Plissner and Susan M. Haig**

**Abstract**: Methods for monitoring progress toward recovery goals are highly variable and may be problematic for endangered species that are mobile and widely distributed. Recovery objectives for Piping Plovers (*Charadrius melodus*) include attainment of minimum population sizes within specified recovery units, as determined by two U.S. and two Canadian recovery teams. To assess progress toward these goals, complete surveys of the species' winter and breeding ranges in Canada, the United States, Mexico, the Bahamas, and the Greater Antilles are conducted every 5 years. In 1996, 1200 biologists and volunteers participated in the second International Piping Plover Census, tallying 2515 wintering birds and 5913 adults (2668 breeding pairs) during the breeding census. Winter numbers were 27% lower than those of the first international census conducted in 1991, with substantially fewer wintering birds along the Gulf of Mexico and an overall increase in numbers along the Atlantic Coast. Large numbers of wintering plovers remain undetected. In 1996, the total number of breeding adults was 7.7% higher than in 1991. Regionally, breeding numbers were 31% higher along the Atlantic Coast and 20% higher in the small Great Lakes population, but declined by 5% in the U.S. Great Plains and the Canadian Prairie. Target recovery numbers were met only for Saskatchewan but were approached in Alberta and New England. The results suggest that Piping Plover distribution and habitat use in the U.S. Great Plains/Canadian Prairie region may shift dramatically with water conditions.

**Résumé** : Le méthodes d'évaluation des progrès d'entreprises de réhabilitation sont très variables selon le but à atteindre et peuvent s'avérer problématiques chez les espèces menacées qui sont mobiles et qui ont une vaste répartition. Les tentatives de rétablissement du Pluvier siffleur (*Charadrius melodus*) visent entre autres le retour à des populations minimales à l'intérieur d'unités de rétablissement pré-établies, telles que déterminées par deux équipes américaines et deux équipes canadiennes. Pour évaluer le progrès vers ces objectifs, des inventaires complets des zones d'hiver et des zones de reproduction au Canada, aux États-unis, au Mexique, dans les Bahamas et dans les Grandes Antilles se font tous les 5 ans. En 1996, 1200 biologistes et volontaires ont participé au second recensement international du Pluvier siffleur et ont repéré 2515 oiseaux dans leurs territoires d'hiver et 5913 adultes (2688 couples reproducteurs) au cours de la saison de reproduction. Le nombre d'oiseaux en hiver a été de 27% moins élevé qu'au cours du premier inventaire international en 1991; il y a eu beaucoup moins de pluviers le long du golfe du Mexique, mais une augmentation générale du nombre d'oiseaux le long de la côte atlantique. Un grand nombre de pluviers ne sont pas détectés en hiver. Le nombre total d'adultes reproducteurs a été de 7,7% plus élevé en 1996 qu'en 1991. Localement, le nombre de reproducteurs a été de 31% plus élevé le long de la côte atlantique et de 20% plus élevé au sein de la petite population des Grands Lacs, mais de 5% plus faible dans les grandes prairies, aux É.-U. et au Canada. Le nombre d'oiseaux visé dans l'opération réhabilitation a été atteint seulement en Saskatchewan, mais presque atteint en Alberta et en Nouvelle-Angleterre. Les résultats indiquent que la répartition du Pluvier siffleur et son utilisation de l'habitat dans les grandes prairies, au Canada et aux É.-U., peuvent fluctuer de façon considérable en fonction des conditions hydriques.

[Traduit par la Rédaction]

## Introduction

Goals for the recovery of populations that have undergone substantial declines typically focus on attaining a designated minimum population size. Under the U.S. Endangered Species Act, recovery objectives for listed species must include "objective, measurable criteria" for delisting (Endangered Species Act Section 4, §16 U.S.C. 15.33 (f) (1)); however, data needed to establish and meet such criteria are lacking for most species (Tear et al. 1993; National Research Coun-

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cil Committee on Scientific Issues in the Endangered Species Act 1995). Although many recent recovery plans and revisions have attempted to base objectives on population viability analyses and other demographic modeling tools, demographic data needed to accurately model population trends are rarely available, and goals for most species are still based to some degree on estimates of historic abundance and distribution. Furthermore, there is no standardized protocol for determining how meeting such criteria should be assessed. Designing monitoring strategies for species with localized distributions may not be particularly difficult. However, the design and implementation of appropriate monitoring efforts can be prohibitive for wide-ranging and migratory species, yet they are critical for assessing progress toward achieving recovery.

Piping Plovers (*Charadrius melodus*) are federally listed migratory shorebirds, whose broad North American distribution illustrates the need, difficulty, and benefit of conducting periodic comprehensive monitoring of progress toward recovery. The species breeds in 20 U.S. states and 9 Canadian provinces on isolated sand beaches, river sandbars, and shores of alkali lakes and winters along the coasts of the southern United States, northeastern Mexico, and the nations of the Greater Antilles.

In 1985, Piping Plovers were listed under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service 1985) and in 1988 two recovery plans, one for the U.S. Atlantic Coast (U.S. Fish and Wildlife Service 1988*a*) and a second for the Great Lakes and Northern Great Plains (U.S. Fish and Wildlife Service 1988*b*), were approved. Recovery teams for Atlantic and Prairie Canada populations of the species produced a Canadian recovery plan the following year (Atlantic and Prairie Piping Plover Recovery Teams 1989). Recovery objectives for all four jurisdictions were originally based upon historic documentation of population sizes and distributions and were modified based upon consideration of habitat loss and degradation. Proposed and accepted revisions of these plans have also incorporated objectives designed to minimize risk of extinction through demographic and genetic processes (U.S. Fish and Wildlife Service 1994, 1996; Goossen et al.[2]). Within each region, target population sizes have been further divided among geographic recovery units that generally follow political boundaries.

In the U.S. Great Lakes/Northern Great Plains plan, downlisting is predicated on maintaining recovery goals over a 15-year period that includes a minimum of three large-scale censuses (U.S. Fish and Wildlife Service 1988*b*). In 1990, the four recovery teams began collaboration on the development of a range wide survey of the species across all suitable habitat every 5 years, for the purpose of determining the species distribution and monitoring progress toward recovery. The first International Piping Plover Census, conducted in 1991, was designed by the U.S. Great Lakes/Northern Great Plains Piping Plover Recovery Team and was conducted throughout the known winter and summer ranges of the species (Haig and Plissner 1993). A census design focusing on narrowly delineated time periods was chosen to provide counts of all populations during winter and summer seasons. Duplicate counts of individuals were minimized by limiting survey efforts to a 3-week time period ("window") when migratory and postbreeding movements were unlikely. The 1991 census accounted for 3451 wintering and 5488 breeding individuals and was the most extensive census taken of any North American endangered species.

In 1996, the second International Piping Plover Census was conducted, with the primary goal of providing data comparable with that of the 1991 census and thus allowing local, regional, and global assessments of progress toward achieving population recovery objectives. Additionally, census results were to be used to indicate where additional or new efforts might be needed and to provide an example of how a seemingly daunting task could be successfully executed to provide critical information for the recovery of endangered species.

## Methods

The 1996 International Piping Plover Census followed guidelines developed for the 1991 census (Haig and Plissner 1993) and was coordinated through the four U.S. and Canadian Piping Plover recovery teams. Priorities for census coverage included all sites known to have supported Piping Plovers during or since the 1991 census and areas that were known to have had suitable habitat (U.S. Fish and Wildlife Service 1988*b*, 1996) in 1991 or later. Census coordinators were designated for all areas where Piping Plovers were known or presumed to breed or winter (Haig and Oring 1985; Haig 1992), including 27 U.S. states, 9 Canadian provinces, eastern Mexico, and 5 nations and territories of the West Indies and northwestern Atlantic Ocean. These individuals subsequently organized local survey efforts, provided standardized forms and guidelines to individual census takers, and collected and presented results to the primary census coordinator (J.H.P.).

Local observers were asked to conduct a single survey of a specified site sometime within the designated census period. Sites were not uniformly defined and thus represented from <0.5 to 270 km of shoreline. Observers were asked to provide an exact count of the number of adult Piping Plovers present, while minimizing the potential disturbance of birds and avoiding extreme weather conditions. Census takers also indicated which areas were surveyed on maps, to facilitate general mapping of results and comparisons with past and future censuses. Additional information was collected on census time, weather and tidal conditions, general habitat characteristics, the extent of the area in which the census was taken, the identification of banded individuals, and observations of injured birds. Detailed data summaries and maps are presented in Plissner and Haig (1997).

Censuses were conducted during two periods, which corresponded to midwinter and midbreeding seasons. The 1996 winter census was conducted prior to the breeding census, as was that of 1991, to allow intrayear comparisons without the confounding effects of young birds of the year. In 1996, 15–21 January was designated as the primary period for the winter census, but counts completed during the weeks immediately prior to or following the census window were also permitted. Data from a few censuses conducted at remote sites on dates outside this period were also accepted, if it appeared unlikely that birds would have been counted elsewhere during the census period. The winter census was con-

[2] J.P. Goossen, D.L. Amirault, J.E. Arndt, R. Bjorge, J.S. Boates, J. Brazil, S. Brechtel, G.N. Corbett, F.R. Curley, S.P. Flemming, W. Harris, L. Heyens, D. Hjertaas, M. Huot, R. Jones, W. Koonz, P. Laporte, D. McAskill, R.I.G. Morrison, S.G. Richard, L. Swanson, and E. Wiltse. Canadian Piping Plover recovery plan. Recovery of Nationally Endangered Wildlife Committee, Ottawa, Ont. In preparation.

**Table 1.** Summary of the 1996 International Piping Plover Winter Census.

| Location | No. of Piping Plovers | No. of sites censused | No. of sites with Piping Plovers | No. of linear kilometres surveyed[a] | No. of participants in the census | Coordinator |
|---|---|---|---|---|---|---|
| U.S.A. | 2416 | 319 | 116 | 3197.7 | 375 | |
| North Carolina | 50 | 32 | 10 | 456.2 | 22 | D. Allen |
| South Carolina | 78 | 25 | 13 | 117.0 | 7 | P. Wilkinson |
| Georgia | 124 | 14 | 9 | 144.6 | 61 | M. Harris, T. Johnson |
| Florida | 375 | 112 | 33 | 860.2 | 156 | K. Owens |
| Atlantic Coast and Keys | 31 | 51 | 6 | 444.0 | 89 | |
| Gulf Coast | 344 | 61 | 27 | 416.2 | 67 | |
| Alabama | 31 | 2 | 2 | 7.6 | 1 | R. Clay |
| Mississippi | 27 | 15 | 4 | 224.0 | 23 | M. Woodrey |
| Louisiana | 398 | 31 | 13 | 225.9 | 32 | C. Shively |
| Texas | 1333 | 85 | 32 | 1146.2 | 71 | L. Elliott |
| Puerto Rico | 0 | 3 | 0 | 16.0 | 2 | J. Saliva |
| Bahamas | 17 | 10 | 8 | na | 30 | C. Wardle |
| Cuba | 66 | 10 | 3 | 106.5 | 2 | P. Blanco |
| Jamaica | 0 | na | 0 | na | na | C. Levy |
| Bermuda | 0 | na | 0 | na | 1 | D. Wingate |
| Tamaulipas, Mexico | 16 | 2 | 2 | 23.0 | 2 | E. Carrera |
| Total | | | | | | |
| Atlantic and Caribbean coasts | 366 | 145 | 49 | 1268.3 | 212 | |
| Gulf of Mexico | 2149 | 196 | 80 | 2058.9 | 198 | |
| Grand total | 2515 | 341 | 129 | 3327.2 | 410 | |

[a]Minimum estimate; data are not available (na) for some sites.

ducted along the southeast Atlantic and Gulf coasts of the U.S.; Puerto Rico; coastal Tamaulipas, Mexico; Cuba; and the Bahamas. Requests for sightings were sent to key individuals in Jamaica, Bermuda, Dominican Republic, the U.S. Virgin Islands, and the Mexican states of Yucatan, Sonora, and Sinaloa, as well as through several local and national ornithological newsletters.

For the breeding census, surveys were conducted during the week of 1–9 June 1996, although observations from the following week were also accepted. In many areas, Piping Plover breeding phenology is monitored throughout the season, and monitors provided information on birds known to be present during the census week. The breeding census covered known and potential breeding areas along the Atlantic Coast from Newfoundland to North Carolina and along shorelines of the western Great Lakes, Lake of the Woods (in Minnesota and Ontario), and suitable wetlands, reservoirs, and rivers of northern U.S. Great Plains States and the Canadian Prairie Provinces.

During the breeding census, observers were discouraged from searching for nests and young, in order to reduce their impact at sites. Historically, factors used to determine Piping Plover pair status have differed between Atlantic Coast and inland regions. Thus, in 1996, census takers were also asked to provide more specific information on the designation of pairs observed, to facilitate comparisons between years and across populations. Specifically, observed unpaired birds were recorded as being seen either with nests or young or without nests or young present. We derived figures corresponding to counts of "breeding pairs" by combining numbers of paired birds and numbers of individuals seen with nests or young, as defined by the Atlantic Coast Recovery Plan (U.S. Fish and Wildlife Service 1996).

While the populations of the Atlantic Coast and Great Lakes have been extensively surveyed and monitored since the mid-1980s, the 1991 census was the first comprehensive survey of the entire Canadian Prairie and U.S. Northern Great Plains region and served, in large part, to identify areas to be included and excluded from future censuses (Haig and Plissner 1992). Nevertheless, changes in water levels left many of the U.S. Northern Great Plains – Canadian Prairie sites surveyed in 1991 without suitable nesting habitat. In 1996, precensus assessments, including aerial surveys in Alberta and Saskatchewan, were used to identify potential breeding habitat and delimit coverage in many areas and resulted in the exclusion of many 1991 census sites. Therefore, although coverage of specific areas varied extensively between 1991 and 1996, nearly all sites with potential Piping Plover habitat were surveyed in both years.

We compared 1996 census results to those obtained from the first International Piping Plover Census. We also used Audubon Christmas Bird Count (CBC) data for comparisons with winter census results and for analyses of population trends. Preliminary correlation analyses demonstrated no significant overall effects of observer number, party-hours, or party-miles on numbers of Piping Plovers observed, so we used simple linear regression models focused on CBC locations with continuous coverage since 1980.

## Results

### Winter census

For the winter portion of the census, over 400 observers covered 341 sites across more than 3300 km of shoreline (Table 1): along the U.S. Atlantic coast and the Gulf coasts of the U.S. and Tamaulipas, Mexico, and in Bermuda, northern Cuba, Puerto Rico, and the Bahamas (Fig. 1). Overall, 2515 Piping Plovers were located (Fig. 1). No birds were found in Puerto Rico, Jamaica, or Bermuda, despite efforts to find them in appropriate habitats. Most (53%) of the birds

**Fig. 1.** Piping Plover winter and breeding distribution, based on the results of the 1996 International Piping Plover Census.

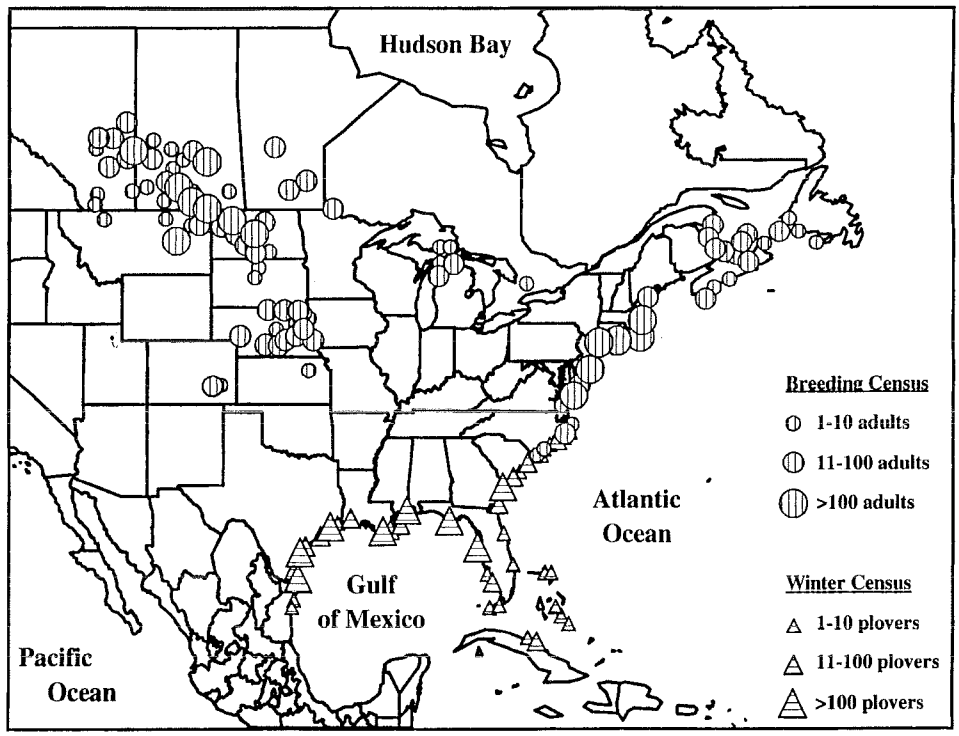



**Table 2.** Major Piping Plover wintering areas in 1996.

| Site name | State | No. of birds | % total | No. of linear kilometres covered | No. of birds/km |
|---|---|---|---|---|---|
| West side of South Padre Island, north end of Hwy. 100 to Los Bancos Island | Tex. | 314 | 12.5 | 70.8 | 4.4 |
| San Jose Island, North Pass area | Tex. | 274 | 10.9 | 6.0 | 45.7 |
| South Bay | Tex. | 106 | 4.2 | ? | ? |
| Upper Laguna Madre, Bird Island Basin to JFK Causeway | Tex. | 104 | 4.1 | 24.1 | 4.3 |
| Bolivar Peninsula | Tex. | 101 | 4.0 | 30.6 | 3.3 |
| Chandeleur Island (Breton National Wildlife Refuge) | La. | 87 | 3.5 | 24.1 | 3.6 |
| West Timbalier Island | La. | 84 | 3.3 | 9.7 | 8.7 |
| West side of South Padre Island, boat ramp to north end of Hwy. 100 | Tex. | 79 | 3.1 | 17.7 | 4.5 |
| Lanark Reef | Fla. | 58 | 2.3 | 4.0 | 14.5 |
| Kleberg County mud flat north of Padre Island National Seashore boundary | Tex. | 58 | 2.3 | 5.6 | 10.4 |
| Mustang Island, bayside | Tex. | 50 | 2.0 | 12.9 | 3.9 |

were found in Texas, where the majority of sites with more than 50 birds present were also found (Table 2), although overall densities of plovers were often higher at Florida census sites. The number of wintering birds observed represents 42.5% of the total number of breeding adults reported during the breeding portion of the census.

Eighty percent of the birds were observed on sandy substrates, particularly sand flats, yet only 23% of individuals were found along ocean beaches. Fifty percent of the birds were located on tidal flats with sand, mud, or algal substrates in protected bays and lagoons, while another 20% of the birds were found along coastal sand and mud flats.

## Breeding census

In June 1996, over 800 participants surveyed more than 2200 km of Atlantic coastline; 1926 km of river habitat; 2196 km of major reservoir shoreline; and 121 beaches along the Great Lakes, Lake of the Woods (in Minnesota and Ontario), and major Manitoba lakes, as well as along beaches of 590 smaller water bodies (Table 3). During the census

**Table 3.** Summary of the 1996 International Piping Plover Breeding Census.

| Location | No. of adults | No. of breeding pairs | No. of sites surveyed | No. of sites with Piping Plovers | No. of linear kilometres covered[a] | No. of participants in the census | Coordinator |
|---|---|---|---|---|---|---|---|
| Atlantic | 2581 | 1270 | 707 | 331 | 2 271.8 | 423 | |
| St. Pierre and Miquelon | 6 | 3 | 3 | 1 | 23.5 | 3 | R. Etcheberry |
| Atlantic Canada | 422 | 189 | 291 | 93 | 806.2 | 206 | |
| Newfoundland | 27 | 11 | 22 | 7 | 45.1 | 16 | J. Brazil |
| Quebec | 104 | 51 | 45 | 13 | 236.4 | 46 | P. Laporte |
| Prince Edward Island | 66 | 29 | 73 | 19 | 185.9 | 60 | D. Waddell |
| New Brunswick | 146 | 65 | 52 | 29 | 196.3 | 42 | D. Amirault |
| Nova Scotia | 79 | 33 | 99 | 25 | 142.5 | 42 | S. Boates |
| U.S. Atlantic | 2153 | 1078 | 413 | 237 | 1 442.1 | 214 | |
| Maine | 114 | 57 | 25 | 18 | 31.6 | 7 | J. Jones |
| Massachusetts | 877 | 437 | 126 | 82 | 370.1 | 57 | S. Melvin |
| Rhode Island | 91 | 45 | 13 | 10 | 29.6 | 7 | C. Raithel |
| Connecticut | 42 | 20 | 19 | 7 | 20.9 | 6 | J. Victoria |
| New York | 493 | 256 | 118 | 69 | 339.7 | 57 | M. Alfieri |
| New Jersey | 209 | 103 | 43 | 23 | 135.6 | 26 | D. Jenkins |
| Delaware | 8 | 4 | 17 | 2 | 59.2 | 11 | L. Gelvin-Innvaer |
| Maryland | 91 | 50 | 1 | 1 | 45.0 | 6 | J. Kumer |
| Virginia | 155 | 72 | 21 | 12 | 147.6 | 11 | B. Cross |
| North Carolina | 73 | 34 | 30 | 13 | 262.8 | 26 | D. Allen |
| Great Lakes | 48 | 21 | 85 | 15 | 119.2 | 34 | |
| Canada (Ont.) | 1 | 0 | 14 | 1 | 24.7 | 18 | L. Heyens |
| U.S.A. | 47 | 21 | 71 | 14 | 94.5 | 16 | |
| Michigan | 47 | 21 | 59 | 14 | 94.5 | 14 | K. Stubbs |
| Wisconsin | 0 | 0 | 12 | 0 | na | 2 | S. Matteson |
| Great Lakes – Great Plains | 3284 | 1377 | 837 | 325 | 7 893.9 | 351 | |
| Canadian Prairie | 1687 | 679 | 415 | 112 | 3 462.6 | 207 | |
| Alberta | 276 | 120 | 106 | 31 | 752.3 | 60 | R. Bjorge |
| Saskatchewan | 1348 | 534 | 276 | 69 | 2 642.8 | 128 | M. Skeel, E. Wiltse |
| Manitoba | 60 | 24 | 29 | 11 | 57.5 | 16 | R. Jones |
| Ontario | 3 | 1 | 4 | 1 | 10.0 | 3 | L. Heyens |
| U.S. Great Plains | 1597 | 698 | 422 | 213 | 4 431.3 | 144 | |
| Montana wetlands and small reservoirs | 129 | 52 | 68 | 22 | 430.7 | 26 | L. Hanebury |
| North Dakota wetlands | 879 | 398 | 121 | 62 | 456.2 | 42 | M. Johnson, K. Olson |
| Missouri River (Mont., N.Dak., S.Dak., Nebr.) | 185 | 77 | 76 | 65 | 2 513.0 | 29 | C. Kruse |
| South Dakota wetlands | 0 | 0 | 15 | 0 | 18.1 | 8 | N. McPhillips |
| Nebraska | 366 | 155 | 101 | 57 | 897.6 | 28 | J. Dinan |
| Iowa | 14 | 7 | 2 | 2 | 2.4 | 2 | D. Howell |
| Colorado | 13 | 3 | 35 | 3 | 104.6 | 5 | C. Aid |
| Kansas | 1 | 1 | 1 | 1 | 0.7 | 1 | W. Busby |
| Minnesota | 10 | 5 | 3 | 1 | 8.0 | 3 | S. Maxson |
| Total | | | | | | | |
| U.S.A. | 3797 | 1797 | 906 | 464 | 5 967.9 | 374 | |
| Canada | 2110 | 868 | 720 | 206 | 4 293.5 | 431 | |
| France | 6 | 3 | 3 | 1 | 23.5 | 3 | |
| Grand total | 5913 | 2668 | 1629 | 671 | 10 284.9 | 808 | |

[a]Minimum estimate; data are not available for some sites.

period, 5913 adult Piping Plovers, including an estimated 2668 breeding pairs, were observed in 20 U.S. states, 9 Canadian provinces, and the French territory of St. Pierre and Miquelon (Fig. 1; Table 3). Across the breeding range, 56% of the birds (3284 individuals; 1377 pairs) were observed in the U.S. Northern Great Plains and Canadian Prairie region,

**Table 4.** Major Piping Plover breeding sites in 1996.

| Site name | State or province | Total no. of adults | No. of linear kilometres covered | No. of adults/km | % regional total | % total breeding population |
|---|---|---|---|---|---|---|
| U.S. Great Plains and Canadian Prairie | | | | | | |
| Big Quill Lake | Sask. | 435 | 122.70 | 3.5 | 13.2 | 7.4 |
| Chaplin Lake | Sask. | 205 | 62.40 | 3.3 | 6.2 | 3.5 |
| Willow Bunch Lake | Sask. | 124 | 113.40 | 1.1 | 3.8 | 2.1 |
| Appam Lake | N.Dak. | 105 | 11.50 | 9.1 | 3.2 | 1.8 |
| John E. Williams Preserve – Pelican Lake | N.Dak. | 80 | ? | ? | 2.4 | 1.4 |
| John E. Williams Preserve – Lake Williams | N.Dak. | 75 | ? | ? | 2.3 | 1.3 |
| Lake Diefenbaker | Sask. | 75 | 256.00 | 0.3 | 2.3 | 1.3 |
| Manitou Lake | Sask. | 63 | 77.00 | 0.8 | 1.9 | 1.1 |
| Atlantic Coast | | | | | | |
| Assateague Island National Seashore | Md. | 91 | 45.00 | 2.0 | 3.5 | 1.5 |
| Sandy Hook National Recreation Area | N.J. | 74 | 4.02 | 18.4 | 2.9 | 1.3 |
| Crane Beach | Mass. | 66 | 9.00 | 7.3 | 2.6 | 1.1 |
| South Beach, Chatham | Mass. | 64 | ? | ? | 2.5 | 1.1 |
| Westhampton Island West | N.Y. | 58 | 9.65 | 6.0 | 2.2 | 1.0 |
| Race Point Beach | Mass. | 48 | 16.10 | 3.0 | 1.9 | 0.8 |
| Sandy Neck | Mass. | 47 | 14.00 | 3.4 | 1.8 | 0.8 |
| Metompkin Island | Va. | 43 | 13.00 | 3.3 | 1.7 | 0.7 |

while 44% (2581 individuals; 1270 pairs) were observed along the Atlantic Coast and 0.8% (48 individuals; 21 pairs) were observed along the shores of the Great Lakes.

Saskatchewan reported the highest total number of birds observed for any province or state. The three sites with the greatest numbers of Piping Plovers present were also located there (Table 4), although higher breeding densities were generally found at sites along the U.S. Atlantic coast. Fifty-one percent of the breeding pairs were found at locations with less than 10 pairs present and 9% were found at sites containing a single pair.

Of the specific population objectives set by the recovery teams, the target population size was only achieved in 1996 for Saskatchewan, which surpassed its goal by 12%. Population numbers in Montana also surpassed the minimum size set by the original recovery plan but were far below the objective proposed in draft revisions of the plan (U.S. Fish and Wildlife Service 1994). Target populations were also approached in Alberta (92%) and New England (89%). Overall, Piping Plover numbers in 1996 were 63.5% of Atlantic Coast, 14% of Great Lakes, and 60% of U.S. Northern Great Plains and Canadian Prairie recovery goals.

*Atlantic Coast breeding populations*

Along the Atlantic Coast, 2581 individuals and 1270 breeding pairs of Piping Plovers were observed by 423 census takers, during over 1170 party-hours of survey effort (Table 3). General habitat information was provided for approximately 95% of the birds reported. Of these, 71% were reported from sites along open ocean, 15.4% were found on shores of protected bays and inlets, and 12.6% were associated with sites containing both types of coastline. Barrier beaches, either as islands or extensions of mainland, supported 67% of the birds; 18% were found on mainland shores; and other islands and small bars accounted for 8 and 2%, respectively. Atlantic Coast Piping Plovers were primarily associated with sandy substrates (71%). Mixed-sand and gravel–cobble substrates accounted for 11.3% of the birds, 5% were found on mud flats or mixed sand and mud, and less than 2% were found on gravel or cobble. Substrate type was unknown for 11% of the birds observed.

*Great Lakes breeding populations*

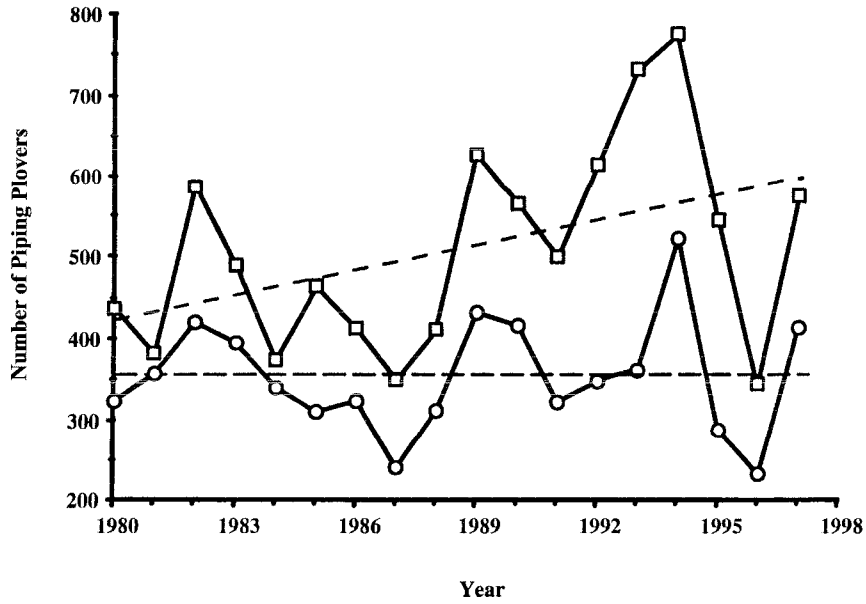
Surveys of the Great Lakes included coverage of 39 beaches on Lake Michigan, 26 on Lake Superior, 17 on Lake Huron, and 2 on Lake Erie. The 48 Piping Plovers reported were observed at 15 locations, with no more than 7 birds being observed at any single site. All but one of the birds were observed in northern Michigan, on Lake Michigan (primarily), and the Lake Superior shoreline of the Upper Peninsula. The other individual observed in the region was identified at a sewage pond in Beaverton, Ontario, east of Lake Huron. Despite subsequent attempts to relocate it, the bird was only observed during one afternoon period and was therefore most likely a migrant.

A survey was conducted at Long Point Bird Observatory on Lake Erie, where Piping Plovers last bred in 1977; however, no birds were observed. Census takers failed to find plovers on the Canadian shores of Lakes Superior and Huron during the first extensive survey of suitable breeding in the region. Piping Plovers also appeared to be extirpated from Wisconsin, where only a single individual was reported during the previous census, and none were observed in 1996.

*U.S. Northern Great Plains and Canadian Prairie breeding populations*

In 1996, 351 participants spent over 2100 party-hours surveying nearly all areas known to have suitable breeding

**Fig. 2.** Total numbers of Piping Plovers reported during Christmas bird counts at all sites (open squares) and at sites ($n$ = 44) surveyed during all years (1980–1997) (open circles). Dashed lines indicate the linear regressions.




habitat in the U.S. Northern Great Plains and Canadian Prairie region (Table 3). Censuses covered stretches and reservoirs of the Missouri River in Montana, North Dakota, South Dakota, and Nebraska, as well as the South Saskatchewan, Platte, Loup, Elkhorn, Niobrara, and Lower Yellowstone rivers. Coverage of suitable off-river wetland habitats was also comprehensive. Saskatchewan had by far the greatest number of breeding Piping Plovers of any state or province, with 41% of the U.S. Northern Great Plains – Canadian Prairie population and 23% of all breeding birds. Concentrations of more than 60 birds were found in Saskatchewan and North Dakota (Table 4). Big Quill Lake, Saskatchewan, had the greatest number of Piping Plovers of any water body, with 435 birds being present during the census period.

Seventy-eight percent ($n$ = 2569) of the U.S. Northern Great Plains/Canadian Prairie Piping Plovers were found along the shores of alkali lakes and other small natural water bodies. Eight percent ($n$ = 268) were found along river shores and bars, and 7.1% ($n$ = 233) were observed along the shores of reservoirs. Four percent were associated with industrial ponds ($n$ = 14) or sand and gravel pits ($n$ = 126), and 1.4% ($n$ = 47) were observed on the major lakes of Manitoba and at Lake of the Woods (Minnesota and Ontario).

## Census comparisons

*Winter populations*

The numbers of wintering Piping Plovers reported in the 1996 winter census were substantially lower (27%) than those found during the 1991 census (Haig and Plissner 1992). As a result of poor weather conditions, a U.S. federal government furlough, and other factors, coverage of many regions in 1996 was less thorough than during the previous census. In 1996, 106 sites that had accounted for 458 birds in 1991 were not surveyed. Nevertheless, a comparison of sites surveyed in both census years still indicated a reduction of 764 birds (25%). Regionally, numbers of Piping Plovers were higher (+68%) than in 1991 along the Atlantic Coast and in the Caribbean; however, these only accounted for 15% of the total winter population. Comparisons of sites surveyed during the two international censuses indicated that increases in the number of birds had occurred in Georgia and the Carolinas, with decreases having occurred primarily along the Gulf Coast.

CBC data provided an index against which to compare international census results, although CBC totals never exceeded 16% of the breeding population for any year. The number of Piping Plovers observed during the 1995–1996 CBC was substantially smaller than that reported for 1990–1991, thus confirming the results of the 1996 international census. For CBC locations surveyed during the year prior to each international census, numbers were 40% lower in 1996 (297 plovers in 1996; 492 in 1991), with reductions of 12% at Atlantic Coast locations ($n$ = 16 count circles) and 44% at locations along the Gulf Coast ($n$ = 20 count circles). However, although CBC totals for 1996 were the lowest recorded in 20 years, the 1997 totals showed an increase of 78% over the previous year.

Since 1980, overall numbers of Piping Plovers reported during the CBC have tended to increase (Fig. 2; $r$ = 0.43, $F$ = 3.67, $n$ = 18, $P$ = 0.07). During this time period, however, the awareness of Piping Plovers as a species of concern has increased, potentially influencing efforts to locate individuals. The increase in numbers reported is also confounded by variability in the numbers of surveys conducted each year. Limiting analysis to only those locations ($n$ = 44) participating in all years of the time period (1980–1997), we found no evidence of any trend in numbers of plovers (Fig. 2; $F$ = 0.018, $n$ = 18, $P$ = 0.90). We did find a significant decrease in the number of those sites that had Piping Plovers present during the time period (Fig. 3; $F$ = 35.80, $n$ = 18, $P$ < 0.001), suggesting that wintering populations have become more concentrated at fewer locations.

**Fig. 3.** Number of Christmas bird count (CBC) circles (out of 44 locations surveyed all years) with Piping Plovers observed during the count day (1980–1997). The dashed line indicates the linear regression.

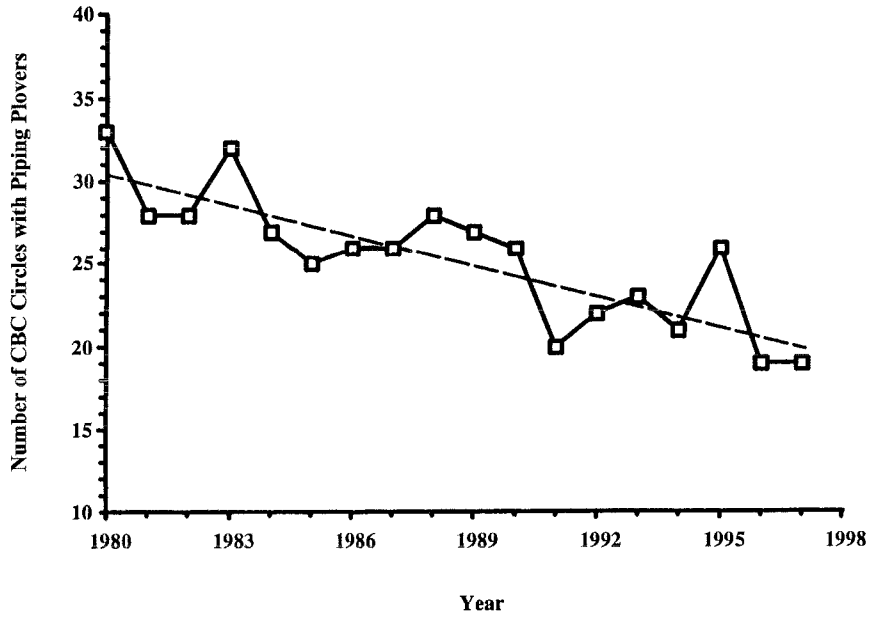



**Table 5.** Changes in total numbers of Piping Plovers at sites surveyed in 1991 and 1996.

| | No. of sites with a change in the no. of adults between 1991 and 1996[a] | | | | |
|---|---|---|---|---|---|
| Region | Declined | No change | Increased | Sites with plovers in 1991 but not in 1996 | Sites with plovers in 1996 but not 1991 |
| Atlantic Coast | 134 | 22 | 154 | 58 | 58 |
| Great Lakes | 7 | 2 | 8 | 5 | 4 |
| U.S. Great Plains – Canadian Prairie | 159 | 17 | 109 | 95 | 52 |
| Total | 300 | 41 | 271 | 158 | 114 |

[a]Number of sites at which birds were present in at least 1 of the 2 census years.

*Breeding populations*

Overall numbers of birds were slightly higher (+7.7%) in 1996 than in 1991; however, this result was not uniform throughout the three regions. On the Atlantic Coast, the 1996 population size was 30.7% larger than that reported for 1991; this was the second highest total recorded since extensive annual censuses were begun in 1986, being superseded only by the 1277 pairs (1077 in the U.S. plus an estimated 199 in Canada) recorded during the 1995 census window period (D. Amirault and A. Hecht, personal communication). In 1996, the total number of birds reported for the Great Lakes represented a net increase of only eight individuals since the 1991 census, despite a more extensive survey effort and high productivity in recent years (F. Cuthbert, personal communication). In the U.S. Northern Great Plains/Canadian Prairie region, 1996 numbers were 5.0% lower than in 1991 and indicated a greater concentration of birds at particular sites (plovers were observed at 425 sites in 1991 and at 325 sites in 1996). Overall, the coverage of potential breeding areas was greater in 1996. Only 17 sites that had birds present in 1991 were not surveyed in 1996, nearly all of which were known to lack suitable habitat during the 1996 census period. Conversely, the 1996 census included at least 225 sites not surveyed in 1991, including 56 at which Piping Plovers were located.

Limiting comparisons to sites surveyed during both census years, the total number of birds was 1.1% lower in 1996 than in 1991 across the species' breeding range. The number of adults was 14% lower in the U.S. Northern Great Plains/Canadian Prairie region (3409 adults in 1991, 2941 in 1996) but higher by 20 and 5% among Atlantic Coast (1952 adults in 1991, 2343 in 1996) and Great Lakes (40 adults in 1991, 42 in 1996) populations, respectively. Of all sites that had birds present in one or both years, the number of plovers observed during the second census was higher at 44%, lower at 49%, and remained the same at 7% of the census locations (Table 5). Increases in numbers of birds between census years were recorded at 50% of Atlantic Coast sites and 47% of Great Lakes sites, but were only noted at 38% of U.S. Northern Great Plains/Canadian Prairie locations; 56% of the sites in the U.S. Northern Great Plains/Canadian Prairie region showed a decline. There was no net difference in the number of areas inhabited by Piping Plovers on the Atlantic Coast or the Great Lakes; however, birds were present at 43 fewer sites in the U.S Northern Great Plains/Canadian Prairie region in 1996 than in 1991.

**Table 6.** Changes in numbers of Piping Plovers at major U.S. Great Plains – Canadian Prairie sites between 1991 and 1996.

| Site | No. of adults in 1991 | No. of adults in 1996 | % change |
|---|---|---|---|
| Lakes | | | |
| Big Quill Lake, Sask. | 151 | 435 | +188 |
| John E. Williams Preserve, N.Dak. | 162 | 242 | +49 |
| Chaplin Lake, Sask. | 113 | 205 | +81 |
| Willow Bunch Lake, Sask. | 31 | 124 | +300 |
| Appam Lake, N.Dak. | 11 | 105 | +855 |
| Lostwood National Wildlife Refuge, N.Dak. | 78 | 75 | –4 |
| Manitou Lake, Sask. | 111 | 63 | –43 |
| Dowling Lake, Alta. | 21 | 54 | +157 |
| Handhills Lake, Alta. | 28 | 54 | +93 |
| Fife Lake, Sask. | 29 | 53 | +83 |
| Medicine Lake, Mont. | 65 | 1 | –98 |
| Rivers | | | |
| Niobrara River, Nebr. | 152 | 107 | –30 |
| Missouri River, Lake Sakakawea to Lake Oahe, N.Dak. | 124 | 45 | –64 |
| Missouri River, Gavins Point to Sioux City, N.Dak. – Nebr. | 165 | 22 | –87 |
| Reservoirs | | | |
| Lake Diefenbaker, Sask. | 276 | 75 | –73 |
| Lake McConaughy, Nebr. | 64 | 69 | +8 |
| Lake Sakakawea, N.Dak. | 162 | 66 | –59 |
| Lake Oahe, S.Dak. – N.Dak. | 101 | 19 | –81 |

In the U.S. Northern Great Plains/Canadian Prairie region, the 1996 distribution of Piping Plovers among various habitat types represented a departure from 1991, when 20% of the birds were located on rivers and adjacent habitats and 18% were associated with large reservoirs (Haig and Plissner 1992). In 1996, these percentages were less than half the 1991 values. These shifts are reflected in differences in numbers at areas of major concentrations during the 2 census years (Table 6). Big Quill Lake had nearly triple the number of birds that had been present 5 years earlier, while Lake Diefenbaker (a reservoir), which had the highest count in 1991 (276 birds), had only 27% of that number in 1996.

## Discussion

### Census methodology

The International Piping Plover Census remains the most extensive concerted survey effort undertaken for any endangered species in North America. It is the only comprehensive shorebird census in North America and is a landmark international cooperative effort between public agencies, private interests, university scientists, and individual volunteers. Although recovery teams have struggled to find consensus on the format and interpretation of results, the numbers generated remain important and revealing in determining the status of populations and directing further conservation efforts. Such comprehensive censuses are necessary to discriminate the status of the species at multiple geographic scales.

In general, and despite flaws, we believe that the International Piping Plover Census adequately depicts population sizes and the distribution of the species. As in 1991, the 1996 breeding census provided nearly 100% coverage of areas that have suitable nesting habitat for Piping Plovers. Nearly all breeding populations of the species are well known and have been monitored more extensively than have birds on the wintering grounds. A 4-year comparison of Atlantic Coast window counts and population estimates from full-season monitoring efforts indicated that results of the window count were consistently near 91% of the breeding season numbers (U.S. Fish and Wildlife Service 1996; Plissner and Haig 1997). While window censuses reduce the probability of double counting individuals that may move between areas during the breeding season (e.g., following an unsuccessful nesting attempt), the latter method includes birds that, for a variety of reasons, may not be observed during a single count period. The two counts, therefore, probably define the bounds within which the actual number of birds falls (U.S. Fish and Wildlife Service 1996). With such close correspondence between the two figures, the international census results appear to accurately represent the actual population sizes of Piping Plovers.

For the winter census, areas with potentially suitable habitat are widespread and difficult to census. The winter distribution outside the United States is poorly known. Coverage of areas in Cuba and the Bahamas in 1996 were the most extensive to date, and the results suggest that additional numbers of plovers are likely to be present. In Texas, winter census efforts were severely hampered by extremely low tides in the Laguna Madre during the census period, which limited access to large areas of suitable habitat and prohibited viewing birds at a range close enough to detect the presence of bands. In Louisiana, poor weather conditions

prevented access to several offshore islands with historically high numbers of birds until well after the census period. While failing to resolve the large-scale issues relating to distribution and population trends, the winter census results nevertheless provided further indications of geographical associations with breeding populations and the potential scale of impact of local threats to concentrations of wintering birds. It also helped by narrowing the focus of future areas in which to search for additional concentrations of wintering birds.

Other large-scale multispecies censuses fail to provide sufficiently accurate information about population trends for Piping Plovers. Breeding-bird surveys are generally inappropriate for assessing shorebird populations, because of both methodological problems and insufficient coverage of major breeding areas (Gill et al. 1995). The International Shorebird Survey program is focused principally on monitoring birds at Atlantic migratory stopover sites, which in general are little used by Piping Plovers. CBCs also fail to provide sufficient coverage of habitats that support the majority of wintering plovers (Haig and Oring 1985; Nicholls and Baldassarre 1990; this study). Nevertheless, long-term monitoring of specific locations may provide some insight into local wintering population trends. General difficulties in interpreting CBC data have been discussed elsewhere (cf. Butcher 1990; Geissler and Sauer 1990).

## Population status

In Atlantic breeding areas, human disturbance and high rates of mammalian and avian predation continue to be primary factors affecting population numbers; however, climatic factors, including cool spring temperatures and atypically high frequencies of storms, have also reduced reproductive success and local numbers in recent years (M. Alfieri, B. Cross, L. Gelvin-Innvaer, J. Jones, and S. Melvin, personal communication). In general, intensive management efforts focused on the protection of nesting areas from human encroachment and the protection of individual nests from disturbance and predation have resulted in increased productivity and subsequent greater population sizes (U.S. Fish and Wildlife Service 1996). Recent declines in some areas may represent oscillations in response to climatic conditions during the breeding season; however, steady declines in Atlantic Canada (U.S. Fish and Wildlife Service 1996; A. Hecht, personal communication; D. Amirault, personal communication) suggest a need for intensified conservation measures.

In the Great Lakes, the small remnant Piping Plover population has remained fairly stable in recent years and has even increased slightly. Although it has failed to expand into other areas with apparently suitable nesting habitat around the Great Lakes, productivity has been consistently high with extensive management (Hathaway Stucker et al. 1998). Great Lakes' birds may be limited by low prey abundance (Nordstrom 1990) and exposure to environmental toxins. Furthermore, the population may be facing the genetic consequences of being a small isolated population, particularly since plover numbers have steadily declined at Lake of the Woods and in Manitoba, the two closest breeding locations and potential links to major Great Plains breeding areas. Banding recoveries and sightings of marked birds do indicate that at least some Great Lakes' birds winter along the mid to southern U.S. Atlantic coast, where mixing with Atlantic Coast breeders may occur (Haig and Plissner 1993; but see Haig and Oring 1988); however, there has never been direct evidence of recruitment of birds from other regions into the Great Lakes population. Observations of a pair nesting on the Apostle Islands, Wisconsin, in 1998 (Hathaway Stucker et al. 1998) indicate that the species may begin to re-establish previously extirpated Great Lakes local populations.

In the U.S. Northern Great Plains and the Canadian Prairie, water levels are the key determinant of Piping Plover presence and productivity (Schwalbach 1988; Higgins and Brashier 1993). On the major rivers and associated reservoirs, water regulation policies determine the breeding success of a large proportion of the regional population. For example, recent water management policies, coupled with naturally high water levels, at Lake Diefenbaker in Saskatchewan have resulted in nearly complete reproductive failure of breeders. Similarly, flow regimes along the Missouri River since 1995 have resulted in the flooding of most plover nests after eggs had been laid (Kruse and Pavelka 1996; N. McPhillips, personal communication). Overall, assessing the regional status of Piping Plovers depends on understanding the success of birds at multiple scales. In any given year, conditions on the major rivers may be drastically different from those on nearby alkali wetlands. Therefore, local site surveys need to be considered in light of longer-term and larger-scale (regional or species-wide) monitoring efforts.

## Census implications

The results of the International Piping Plover Census not only contributed to the census requirements outlined in recovery plans, they provided baseline data for population viability models that are also used in setting recovery objectives. The results of population viability analyses predicted both continued success for intensively managed Atlantic Coast populations as well as further declines in the mid-continent metapopulation (Plissner and Haig 1999). Shifts in habitat distribution patterns of U.S. Northern Great Plains/Canadian Prairie populations between census years emphasize the need to use such models and field methods to understand interactions among populations. The results of the international census also stimulated an increase in the attention paid to monitoring and conserving the species in wintering areas, an aspect that had been largely neglected in recovery efforts. Such attention has resulted in a recent profusion of knowledge about the winter distribution (P. Blanco, personal communication; S.M. Haig and J.H. Plissner, unpublished data) and behavior (K. Drake and K. Drake, personal communication; P. Blanco, unpublished data) of the species, and has significantly furthered the understanding of migratory patterns through increased detection of individuals banded on breeding grounds.

For Piping Plovers and most other endangered species, the development of criteria for delisting is both difficult and controversial (e.g., Tear et al. 1993, 1995; Clark et al. 1995; National Research Council Committee on Scientific Issues in the Endangered Species Act 1995; Taylor 1995). In all cases, monitoring progress toward recovery goals and determining the status of a species or population requires adequate assessment of population numbers. Our results suggest

that comprehensive censuses are necessary for broadly distributed species because derivation of estimates from limited sampling sites may not accurately reflect the overall status of a metapopulation. Surveys conducted during multiple seasons provide critical information on the status of populations and may elucidate threats to species' survival not provided by single-season surveys alone. Although such widespread census efforts appear formidable, by using a network of professionals and volunteers, large-scale surveys can provide a cost-effective and accurate measure of the overall status of endangered species that best indicates the status of recovery efforts.

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